CALCULATING WEEKLY GASEOUS RADIOACTIVE AIR EMISSIONS FROM SAMPLED STACKS AT TA-53

Purpose

This Air Quality Group procedure describes the methods used by ESH-17 to quantify gaseous radioactive air emissions from sampled stacks at LANSCE (TA-53).

Scope

This procedure applies to individuals in the Air Quality Group assigned to perform gaseous emission calculations for LANSCE stacks monitored by the gaseous monitoring system.

In this procedure

This procedure addresses the following major topics:

Hazard Control Plan

The hazard evaluation associated with this work is documented in HCP-ESH-17-Office Work.

Signatures

Prepared by: Dave Fuehne, ESH-17	Date: 7/29/99
Prepared by: Scott Miller, Rad-NESHAP Project Leader	Date: 8/4/99
Approved by: Terry Morgan, QA Officer	Date: 8/5/99
Approved by: Doug Stavert, ESH-17 Group Leader	Date: 8/12/99

08/20/99

General information

Attachments

This procedure has two attachments:

Number	Attachment Title	No. of pages
1	Example of “GMAP” spreadsheet layout	6

History of revision

This table lists the revision history and effective dates of this procedure.

Revision	Date	Description Of Changes
0	8/13/99	New document derived from 53 FMP 104-06.3.

Who requires training to this procedure?

The following personnel require training before implementing this procedure:

- Rad-NESHAP Project personnel performing all or part of this procedure
- ESH-17 LANSCE Coordinator
- Technical reviewer of results

Training method

The training method for this procedure is **on-the-job training** conducted by the preparer or a previously trained individual and is documented in accordance with the procedure for training (ESH-17-024).

General information, continued

Definitions specific to this procedure

Gas emissions: Emissions of gaseous radioactive material, consisting of the following radionuclides: carbon-10, carbon-11, nitrogen-13, nitrogen-16, oxygen-14, oxygen-15, and argon-41.

GMAP: Gaseous Mixed Activation Products. Generic term for the seven radionuclides listed under "Gas emissions," above. Also, the spreadsheet used to analyze the gas emissions for a month is called "GMAP.xls."

MCA, Multi-Channel Analyzer. A detection system which collects, stores, and analyzes time-correlated or energy-correlated event, usually used to describe gamma spectroscopy systems. ESH-17 uses a high-purity germanium (HPGe) detector and Canberra "Genie 2000" software as an MCA system.

PHA, Peak Height Analysis: Type of data acquisition on the MCA that looks at the relative number of detected events over the entire energy spectrum to which the system is calibrated, integrated over the acquisition time. Incident gamma rays are counted in "peaks," with the peak locations and heights indicative of the energy and relative frequency of these incident gammas.

MCS, Multi-Channel Scaling: Type of data acquisition on the MCA that looks at a specific energy range for a prescribed time period (typically 10 seconds or 100 seconds). Counts in this energy range are integrated in one channel for the time period. Then the channel is incremented upward and integration in this energy range begins again in the new channel. This allows analysis of a certain energy gamma peak (typically 511 keV) over time.

DCY, Decay Curve: A special MCS run, taken on an isolated grab sample of gas. Analyzing the relative 511 keV intensities over time allows characterization of the source gas by analysis of relative decay rates. Since a majority of the gas emissions consist of pure positron emitters (C-11, N-13, and O-15), this decay analysis is the only effective method for characterizing the gas composition.

General information, continued

References

The following documents are referenced in this procedure:

- 40 CFR 61, subparts A and H, “National Emission Standards for Hazardous Air Pollutants”
- ESH-17-024, “Personnel Training”
- ESH-17-119, “Evaluation of Radioactive Air Emissions From Sampled Stacks”
- ESH-17-605, “Gamma Spectroscopy Data Collection for Gaseous Emissions at ES-2 and ES-3”
- HCP-ESH-17-Office Work

Note

Actions specified within this procedure, unless preceded with “should” or “may”, are to be considered mandatory guidance (i.e., “shall”).

Calculating emissions

Description of sampling and analysis process

ESH-17 determines the amount of radioactive gases emitted from LANSCE (TA-53) stacks by continuous measurements with a flow-through Kanne ion chamber. The radionuclide composition of the gas is periodically determined using a gamma spectroscopy system on flowing gas as well as on grab samples of gas. The combination of these two measurement systems provides a robust quantitative measurement of LANSCE gaseous emissions.

The officially reportable emission values are determined through the combined analyses of these two methods.

Overview

Based on the stack flow rates, the continuous ion chamber readings, and the inline gamma spectroscopy measurements, the ESH-17 **LANSCE coordinator** or other qualified, trained person calculates the amount of gaseous radioactivity emitted from the stack into the environment using the methodology described in this procedure.

The steps to calculate emissions include:

- gamma spectroscopy to determine the annihilation and nuclide-specific characteristic peaks and quantities,
- a decay analysis of the annihilation peak using multichannel scaling (MCS),
- a gross positron emission measurement with the ion chamber,
- fractional division of the gross ion chamber reading between the positron emitters, and
- combination with the results for nuclides with characteristic gamma radiation.

Gaseous emissions are only determined during beam operation, when the generation of these activated gaseous products are possible.

Calculating emissions, continued

Current stack and sample flow rates

JCNNM determines the maximum pre-cycle stack flow rates for each stack and configuration (ESH-17-127). The ESH-17 **LANSCE coordinator** maintains a record of these flow data and uses the data for effluent calculations. Use the maximum stack flow rate measured by JCNNM during the time period under analysis (Q_{stack}). An online flow rate system, correlated to the JCNNM measurements, confirms the flow rates. The sample flow rate is not used directly in emission calculations, since the measurements are flow-through for the ion chamber and grab for the spectroscopy system. However, the sample flow rate for the ion chamber is set to approximately 6 cfm for ES-3 and 3 cfm for ES-2. These sample flow rates are designed to correspond to the travel time of the effluent to the top of the stack, thus eliminating the need for stack transit decay corrections.

Performing calculations

Calculations referenced in this procedure are normally performed electronically using an Excel spreadsheet named “GMAP.xls” However, these calculations may be done by any means as long as the *methodology* is the same. If done by other means than “GMAP” (such as manually), the analyst must sufficiently document the details of the calculation to demonstrate and allow verification that the *methodology* is the same.

PHA data reduction

In the PHA mode, the MCA stores data as counts vs. energy. Using a previously taken spectrum, determine the net peak areas for the following energies:

- 511 keV annihilation peak
- 718 keV from ^{10}C
- 1296 keV from ^{41}Ar
- 2313 keV from ^{14}O
- 6128 keV from ^{16}N

Retain the peak area report in the “PHA Reports” binder, located in the responsible stack member’s office. The results will be used later.

Calculating emissions, continued

Decay Curve data reduction

In the MCS mode, the spectroscopy system can work as a 511 keV data logger with each new measurement being incremented to the next channel and effectively plotting the decay curve of a grab sample of gas.

Examine the decay curve plot by eye, in at least some cases, to look for problems in the first few bins, or to detect variable background, noise, or defects in the data. Fit the MCS decay curve data with a standard linear regression routine, available in commercial spreadsheet packages.

To perform the fit do the following:

Convert the raw data from the instrument-specific data format to a generic ASCII format using the decay report form in the analysis package of the MCA.

Copy the report file to the data analysis computer, if necessary. Use a text editor, or a special program, to delete the printer control characters (form feeds and similar non-printing codes, which appear as "□" in a text editor). The resulting text file will be streams of data delimited by tabs, spaces, commas, or other appropriate methods. Open this text file in a spreadsheet program for further analysis.

Use a linear regression routine to solve for the coefficients of the decay curve. Most spread sheets provide a linear regression capability (see the appropriate software manual). The fit will find the initial activities (at t=0) for carbon-11, nitrogen-13, and oxygen-15. Note that time zero is equal to bin #21 in the decay file report (see procedure ESH-17-605). The total 511 keV activity measured by the HPGe is as follows:

$$A_{total}(t) = A_{C-11}^{t=0} * e^{-\lambda_{C-11}*t} + A_{N-13}^{t=0} * e^{-\lambda_{N-13}*t} + A_{O-15}^{t=0} * e^{-\lambda_{O-15}*t}$$

where:

$A_{total}(t) =$ the total activity seen by the HPGe

$A_{C-11}^{t=0}, A_{N-13}^{t=0}, A_{O-15}^{t=0} =$ inital activities of C - 11, N - 13, and O - 15

$\lambda_{C-11}, \lambda_{N-13}, \lambda_{O-15} =$ radiological decay constants for C - 11, N - 13, and O - 15

$t =$ time [seconds] after can isolation = 10 * (bin number - 21)

Calculating emissions, continued

Decay Curve data reduction, continued

When performing the regression (described below), the three radionuclide activities are input as x-variables, and the total activity (converted to counts per second) is the y-variable. The regression routine will then calculate best-fit solutions for the three x-variable coefficients, corresponding to the initial concentrations of C-11, N-13, and O-15. The relative percents of each radionuclide are used to determine positron composition.

The decay file output contains the file header followed by a list of channel numbers and counts per channel. Beginning at channel 21 (t=0), add in the following columns of data associated with each channel:

a) counts per second (counts/channel divided by 10 seconds per channel)
b) time (equal to 10 seconds * [channel number-21])
c) remaining fractions of C-11, N-13, and O-15 (equal to exp(-[rad decay constant]*time))

Perform a linear regression on the data, with the three columns of "remaining fractions" as x-input data and the counts per second as the y-input data. The output of the regression will give three x-coefficients, which correspond to the initial activities of C-11, N-13, and O-15. Dividing each coefficient by the sum of the three coefficients gives the relative percent composition of C-11, N-13, and O-15.

File the results from the calculations in the Decay Curve Results binder, maintained in the responsible staff member's office. Each decay file output is also used in the PHA analysis, below.

Calculating emissions, continued

Determining positron emissions

Collect all of the PHA printouts for a given stack configuration. Also, collect the appropriate decay curve results for each stack configuration. The configuration of each PHA and DCY run should be listed in the header blocks of the data acquisition files.

The general equation for calculating emissions of positron emitting nuclides (in microcuries), for a particular configuration, is as follows:

$$E = CF * CG * F$$

where:

E is the total positron emissions in microcuries

CF is the ion chamber calibration factor in ([μCi/cc]/[pC/sec])
(See further explanation below.)

CG is total integrated ion chamber charge in picoCoulombs (corrected for drift).

Stack ion chamber integrator readings are taken daily on RCT surveys of stack instrumentation, and are also recorded by the staff during configuration changes. For each configuration, the start and ending integrated charge is recorded. The corrected charge is found by the equation below. In this equation, “time” is the time between the initial and final integrator readings; the drift rate is the electrometer background, measured before the run cycle and verified periodically during times of no beam operation.

$$\text{Charge} = \text{pC (final)} - \text{pC (initial)} - [\text{Bkgd (drift rate)} * \text{Time}]$$

F is the stack flow rate as measured by JCI, converted to cc/sec. Stack flow is measured by JCI prior to each LANSCE operation cycle.

Calculating emissions, continued

Ion chamber calibration coefficient

The ion chamber calibration coefficient is given by:

$$\text{Calibration} = \frac{\dfrac{511\,\text{keV gammas}}{\text{pC}}}{1.05{*}\varepsilon{*}\rho{*}V{*}2{*}0.98{*}3.7x10^{4}}$$

where:

511 keV gammas /pC is the ratio of 511 keV gammas per picocoulomb, measured with each PHA run and averaged over configuration (typical 1998 values: 112 at ES-3 and 3.7 at ES-2).

1.05 is the surface efficiency divided by the volume efficiency, both calculated using Monte Carlo techniques (determined during system development).

ε is the detector volume efficiency from ^{85}Kr (1996 values: 0.0029 for ES-3; 0.0032 for ES-2).

ρ is the density of air in the sample can divided by the stack air density, (typically 0.98).

V is the sample can volume (5900 cc).

2 is the number of 511 keV gammas produced per decay.

0.98 is the fraction of positrons that decay while at rest, producing 511 keV gammas.

$3.7x10^4$ is the conversion from disintegrations per second to microcuries.

Calculating emissions, continued

Combining results

Compile the PHA composition data for each configuration. These data consist of the number of disintegrations in the 511 keV peak, and the radionuclides having characteristic gammas: ^{10}C, ^{41}Ar, ^{14}O, and ^{16}N. Obtain the number of counts vs. gamma energy from the Canberra software.

Note: If no composition measurements are available for a given configuration for the applicable reporting period, use measurements from previous reporting periods. Compositions for a given configuration do not depend on when they were measured as long as all the parameters such as beam current were unchanged. Water leaks in the target cells may change the radioactive gas composition and, if so, must be considered as separate configurations.

Using the volume efficiencies as a function of gamma energy, compute the number of disintegrations for each of the above radionuclides. (This is done automatically when a yield report is selected from the Canberra Genie/PC).

Calculate the fraction of each radionuclide relative to the number of 511 keV disintegrations as follows:

f(^{10}C) = # disintegrations (^{10}C)/ #511 keV disintegrations
r(^{41}Ar) = # disintegrations(^{41}Ar)/ #511 keV disintegrations
f(^{14}O) = # disintegrations (^{14}O)/ #511 keV disintegrations
r(^{16}N) = # disintegrations (^{16}N)/ #511 keV disintegrations

Note: this is necessary since the gas monitoring system is calibrated by the ratio of 511 keV gammas per picocoulomb collected in the continuously-running ion chamber.

For the non-positron emitters, ^{41}Ar and ^{16}N, normalize the yields to the positron peak and express as a ratio rather than a fraction. The r( ) factors do not enter into the positron sums below.

Compile the decay curve data for each configuration. The fraction of each of the isotopes ^{15}O, ^{13}N, ^{11}C can be copied from the fitting described earlier in this chapter. These fractions by decay will be denoted by fd(^{15}O), fd(^{13}N), and fd(^{11}C).

Calculating emissions, continued

Combining results, continued

The fractions of positron emitters from decay curves add to 100% because no account was taken of the radionuclides ^{10}C and ^{14}O. For each configuration, calculate the fraction represented by the radionuclides ^{15}O, ^{13}N, and ^{11}C as follows:

$$f(^{15}O+^{13}N+^{11}C) = 1 - (f(^{10}C) + f(^{14}O))$$

The fraction of the positron emitters of ^{15}O, ^{13}N, and ^{11}C can now be normalized to:

$$f(^{15}O) = fd(^{15}O) * (1-(f(^{10}C) + f(^{14}O))$$
$$f(^{13}N) = fd(^{13}N) * (1-(f(^{10}C) + f(^{14}O))$$
$$f(^{11}C) = fd(^{11}C) * (1-(f(^{10}C) + f(^{14}O))$$

Calculate the number of curies of each positron emitter from:

$$\# Ci(^{15}O) = \# Ci \text{ (configuration)} * f(^{15}O)$$
$$\# Ci(^{13}N) = \# Ci \text{ (configuration)} * f(^{13}N)$$
$$\# Ci(^{11}C) = \# Ci \text{ (configuration)} * f(^{11}C)$$
$$\# Ci(^{14}O) = \# Ci \text{ (configuration)} * f(^{14}O)$$
$$\# Ci(^{10}C) = \# Ci \text{ (configuration)} * f(^{10}C)$$

The isotopes ^{41}Ar and ^{16}N are not positron emitters. Obtain the number of curies of each by:

$$\# Ci(^{41}Ar) = \# Ci \text{ (positron emitters, configuration)} * r(^{41}Ar)$$
$$\# Ci(^{16}N) = \# Ci \text{ (positron emitters, configuration)} * r(^{16}N)$$

where r( ) is from the PHA data.

To calculate the total number of curies emitted (both positron emitters and non-positron emitters) for a given gas composition and configuration, add the number of curies of ^{41}Ar and ^{16}N to the total number of curies of positron emitters:

$$\text{Total Ci (configuration)} = \# Ci\ (^{41}Ar) + \# Ci\ (^{16}N) + \# Ci \text{ (positron emitters)}$$

Calculating emissions, continued

Combining results, continued

When the above steps are complete for all configurations, sum the curies for each radionuclide. Sum the total number of curies for each composition. This calculates the number of curies for each radionuclide and for total emissions. These numbers are to be reported later.

The fraction of total curies of each radionuclide is of interest and may now be calculated:

$F(^{10}C) = \# Ci(^{10}C) / \text{total curies}$
$F(^{11}C) = \# Ci(^{11}C) / \text{total curies}$
$F(^{13}N) = \# Ci(^{13}N) / \text{total curies}$
$F(^{16}N) = \# Ci(^{16}N) / \text{total curies}$
$F(^{14}O) = \# Ci(^{14}O) / \text{total curies}$
$F(^{15}O) = \# Ci(^{15}O) / \text{total curies}$
$F(^{41}Ar) = \# Ci(^{41}Ar) / \text{total curies}$

Emission correction factors

As described in the *Estimating Missing Data* section of ESH-17-119, “Evaluation of Radioactive Air Emissions From Sampled Stacks,” occasionally a sample period may be incomplete due to equipment malfunction or some other problem. In such cases, a scaling factor or emission correction factor must be developed to allow the emissions to represent an entire sample period. If an emission value has been determined to be invalid, an estimated value, or a replacement value, may be used in its place. Because of the strong correlation between microamp-hours of operation and gaseous emissions at LANSCE, determining a conservative replacement value is relatively easy.

Documenting emissions

Documenting the calculations	The individual performing the calculations in this procedure documents the work performed (normally by printing the spreadsheet) and then forwards the documentation to a technical reviewer (trained to this procedure) for review.
Obtaining technical review of results	The **technical reviewer** checks all the documentation for accuracy and technical correctness. If any data were hand entered, the **technical reviewer** checks all of the entered data. If data were entered or uploaded electronically, the **technical reviewer** checks at least 10% of the entered data.
Forwarding results to project leader and to Records Coordinator	The **ESH-17 LANSCE coordinator** forwards the results to the Rad-NESHAP Project Leader within four weeks of completion and maintains a complete documentation package of all emissions determinations, including analysis results, flow measurements, assumptions, any other information relevant to emission calculations. Periodically forward document packages to the ESH-17 Records Coordinator.
Revising automated calculation methods	After writing or revising an automated (e.g., spreadsheet) calculation method used to calculate emissions at LANSCE, the **ESH-17 LANSCE coordinator** or a qualified, trained designee has a technical reviewer (trained to this procedure) verify the function of the method through hand calculations or other means, and documents these reviews. Comply with all ESH-17 software quality requirements that may be implemented after this procedure is approved.

Records resulting from this procedure

Records

The following records generated as a result of this procedure are to be submitted to the Records Coordinator **within four weeks** after emissions calculations are done:

- Datasheets generated as a result of performing this procedure, including documentation of technical & peer review
- Documentation of peer review of new or revised spreadsheets or other techniques used to calculate emissions
- Documentation of emissions correction factors, if necessary.

Contents of binders and all documentation is maintained in the **LANSCE Coordinator's** office for current and previous year. After this time, records are sent to the TA-53 RAEM records center. Additional routine copying of notebooks is not necessary due to the presence of multiple electronic copies off all records, which are subject to periodic backup.

SAMPLE OF "GMAP" SPREADSHEET LAYOUT

PHA SUMMARY INFORMATION
STACK: ES-3 (53-03-03)
PERIOD: Dec-98
CONFIG: A1/A2 boost off, A2 Damper Open
A6 Boost on; A6 Damper open ; A1 lid closed
Delay Line & Scrubber Off; A6 direct

Peak Energy (keV)->	511	718.3	1293.6	2313	6128	
PHA #	P'TRONS	C-10	Ar-41	O-14	N-16	comments
98112401	2.15E+06	4.56E+03	7.63E+03	1.41E+03	6.31E+02	
98112501	3.85E+07	2.41E+05	4.90E+04	5.29E+04	1.01E+04	
98120701	3.93E+07	1.82E+05	6.08E+04	4.10E+04	1.05E+04	
98120901	3.94E+07	1.29E+05	6.58E+04	3.44E+04	1.08E+04	
98121001	6.07E+07	7.11E+05	5.88E+04	1.13E+05	1.72E+04	
98121201	1.08E+08	3.98E+05	1.70E+05	1.00E+05	2.97E+04	
98121401	1.14E+08	3.93E+05	1.72E+05	1.05E+05	2.94E+04	
98121601	8.61E+07	1.56E+05	1.49E+05	6.12E+04	2.35E+04	
98121701	6.57E+07	1.19E+05	1.19E+05	4.44E+04	1.95E+04	
98121801	3.87E+07	6.39E+04	6.98E+04	2.53E+04	1.07E+04	
98121901	3.47E+07	5.53E+04	6.85E+04	2.15E+04	1.19E+04	
98122101	4.78E+07	9.75E+04	1.02E+05	3.11E+04	2.47E+04	
98122301	1.06E+04	0.00E+00	2.28E+02	0.00E+00	0.00E+00	Beam off; vent box.

DATA ENTRY

by: _RWK________________

date: ____________________

DATA Q.A. CHECK

applies to this page
and all subsequent pages

________:PHA data entry

________:stack gas composition

________:integrator readings
________:background calc.
________:stack flow data

____
signature or initials of reviewer

____
Date

EXAMPLE OF "GMAP" SPREADSHEET LAYOUT, CONTINUED

FRACTION OF RADIONUCLIDES
STACK: ES-3 (53-03-03)
PERIOD: Dec-98
CONFIG: A1/A2 boost off, A2 Damper Open
A6 Boost on; A6 Damper open ; A1 lid closed
Delay Line & Scrubber Off; A6 direct

	f(C-10)	r(Ar-41)	f(O-14)	r(N-16)	1-f(C10+O14)	f(O-15)	f(N-13)	f(C-11)
Average	9.70E-03	1.54E-02	6.85E-03	1.74E-02	0.9835	0.3576	0.1845	0.4414
Sigma	8.15E-03	2.46E-02	3.41E-03	6.49E-03				0.9834
								1.0328

	P'TRONS	C-10	Ar-41	O-14	N-16	
					1.15	bootstrap
energy (keV)	511	718.3	1293.6	2313	6128	
yield	2	0.9853	0.9916	0.9934	0.67	
Eff=	3.22E-03	2.28E-03	1.39E-03	7.98E-04	1.54E-04	

Fraction per Run #	0.511	f(C-10)	r(Ar-41)	f(O-14)	r(N-16)
98112401	3.34E+08	6.07E-03	1.65E-02	5.33E-03	1.83E-02
98112501	5.98E+09	1.79E-02	5.92E-03	1.12E-02	1.64E-02
98120701	6.11E+09	1.33E-02	7.20E-03	8.47E-03	1.67E-02
98120901	6.12E+09	9.37E-03	7.77E-03	7.09E-03	1.71E-02
98121001	9.43E+09	3.35E-02	4.51E-03	1.51E-02	1.77E-02
98121201	1.68E+10	1.05E-02	7.32E-03	7.52E-03	1.72E-02
98121401	1.77E+10	9.87E-03	7.02E-03	7.48E-03	1.61E-02
98121601	1.34E+10	5.19E-03	8.05E-03	5.77E-03	1.71E-02
98121701	1.02E+10	5.19E-03	8.43E-03	5.49E-03	1.86E-02
98121801	6.01E+09	4.73E-03	8.39E-03	5.31E-03	1.73E-02
98121901	5.39E+09	4.56E-03	9.19E-03	5.03E-03	2.14E-02
98122101	7.43E+09	5.84E-03	9.93E-03	5.28E-03	3.23E-02
98122301	1.65E+06	0.00E+00	1.00E-01	0.00E+00	0.00E+00

Calibration Eqn
ln(Eff) = A + B*ln(En)
+ C*ln(En)^2
+ D*ln(En)^3
+ E*ln(En)^4
+ F*ln(En)^5

Eff	detector efficiency	
En	gamma energy (keV)	
A		-8.207E+01
B		5.044E+01
C		-1.203E+01
D		1.248E+00
E		-4.833E-02
F		0.000E+00

values from cal file: 98ES3-B.cal

solve for Efficiency:
Eff = exp{ A + B*ln(En)
+ C*ln(En)^2
+ D*ln(En)^3
+ E*ln(En)^4
+ F*ln(En)^5}

also include surface/volume correction @ 511 keV; high energy bootstrap at 6128 keV

EXAMPLE OF "GMAP" SPREADSHEET LAYOUT, CONTINUED

MCS DECAY FRACTIONS
STACK: ES-3 (53-03-03)
PERIOD: Dec-98
CONFIG: A1/A2 boost off, A2 Damper Open
A6 Boost on; A6 Damper open ; A1 lid closed
Delay Line & Scrubber Off; A6 direct

	fd(O-15)	fd(N-13)	fd(C-11)	
AVERAGE	36.36%	18.76%	44.88%	
SIGMA	0.051	0.011	0.042	
FILE #	O-15 %	N-13 %	C-11 %	
				0.0%
98112503	43.4%	17.3%	39.3%	100.0%
98120703	34.4%	19.8%	45.8%	100.0%
98121803	31.3%	19.2%	49.6%	100.0%
98121003	54.2%	14.4%	31.4%	100.0%
98121403	33.9%	19.5%	46.6%	100.0%

Kanne Chamber pC (Net & Background) Calculations
STACK: ES-3 (53-03-03)
PERIOD: Dec-98
CONFIG: A1/A2 boost off, A2 Damper Open
A6 Boost on; A6 Damper open ; A1 lid closed
Delay Line & Scrubber Off; A6 direct

TOTAL
NET pC= 6,814,647
from integrator

Start Date & Time	End Date & Time	Start pC	End pC	Delta Time sec	BKGD pC (bkPc/s)* delta time	Gross Delta pC	Net pC (gross - bkgd pC)
23-Nov-98 00:00	25-Nov-98 09:06	3,960,086	4,408,400	205560	26722.8	448,314	421,591
		A6 ON; delay line OFF					
6-Dec-99 18:46	23-Dec-99 15:38	5,067,400	########	1457520	189477.6	6,582,533	6,393,055
		A6 ON; delay line OFF					

Data entry for this section checked by Dave Fuehne, 1/22/99. All correct.

6,814,647

No electrometer down time, therefore no pC correction via DSRP is required.

Background Calculation

Start Date & Time	End Date & Time	Start pC	End pC	Number Sec	Number pC	Background bkgd pC per sec
1998 pre-operational background: A6 Boost ON, box sealed up.						0.13
see Sept 6, 1998 value. 98day.xls file						

EXAMPLE OF "GMAP" SPREADSHEET LAYOUT, CONTINUED

REPORTING OF pC
STACK: ES-3 (53-03-03)
PERIOD: Dec-98
CONFIG: A1/A2 boost off, A2 Damper Open
A6 Boost on; A6 Damper open ; A1 lid closed
Delay Line & Scrubber Off; A6 direct

Average = 109.9
Sigma = 3.750 3.41%
average & sigma NOT including outlined cells
very conservative, ave only uses the two significant data points

File #	pC Start	pC End	Total pC	Live Time	Real Time	pC/Sec w/BKGD subtracted	511 gammas	511s per LT	511s per pC	Comments	
98112401	3,978,990	4,013,666	34,676	123,772.7	123,872.8	0.15	2.15E+06	17.37055	115.9		0
98112501	4,013,677	4,377,500	363,823	51,177.2	52,929.2	6.74	3.85E+07	752.2881	111.6		0
98120701	5,077,000	5,448,500	371,500	53,444.6	55,211.5	6.60	3.93E+07	735.3409	111.4		0
98120901	5,525,000	5,913,642	388,642	150,311.9	152,075.5	2.43	3.94E+07	262.1216	108.1		0
98121001	5,913,660	6,510,000	596,340	87,938.8	90,790.7	6.44	6.07E+07	690.2528	107.2		0
98121201	6,704,000	7,745,700	1,041,700	165,950.1	170,785.9	5.97	1.08E+08	650.798	109.0		0
98121401	7,747,777	8,854,970	1,107,193	149,071.2	154,197.2	7.05	1.14E+08	764.7352	108.5		0
98121601	8,914,555	9,745,000	830,445	149,761.4	153,597.3	5.28	8.61E+07	574.9145	109.0		0
98121701	9,745,400	10,380,000	634,600	114,716.3	117,640.7	5.26	6.57E+07	572.7172	108.8		0
98121801	10,381,000	10,748,300	367,300	61,125.2	62,844.6	5.71	3.87E+07	633.1268	110.8		
98121901	10,828,500	11,163,600	335,100	75,252.0	76,792.3	4.23	3.47E+07	461.1173	108.9		
98122101	11,116,400	11,626,818	510,418	156,858.2	158,977.3	3.08	4.78E+07	304.7338	98.9	beam off for 2 hours @ end	
98122301	11,626,850	11,647,730	20,880	176,916.6	176,924.2	-0.01	1.06E+04	0.059915	-5.0	all beam off	

EXAMPLE OF "GMAP" SPREADSHEET LAYOUT, CONTINUED

CONSTANT TABLE
STACK: ES-3 (53-03-03)
PERIOD: Dec-98
CONFIG: A1/A2 boost off, A2 Damper Open
A6 Boost on; A6 Damper open ; A1 lid closed
Delay Line & Scrubber Off; A6 direct

EMISSIONS (Ci positron emitters)
calib * charge * stack flow / 1e6 = 4784.806

Total Net pC = 6,814,647
(given configuration)

Electric Drift (pC/s) = 0.13

Stack Flow (cc/s) = 8.16E+06
(cfm) = 17282

CALIBRATION (microCi/cc/pA)= 8.61E-05

CALIBRATION INPUT: 511/Pc 109.9149 +/- 3.749563

Efficiency	0.0029	calc'ed 6/98
air density ratio, sample can to stack	0.98	QAPP
VOL (cc)	5900	QAPP
eff ratio (surf/vol)	1.05	QAPP
# 511 gammas/decay	2	QAPP
%511's that annihilate	98%	QAPP
convert Bq to uCi	3.70E+04	QAPP

conversion, pC to uCi

$$\frac{\text{gamma/pC}}{\text{(eff)*(density ratio)*(volume)*(eff ratio)*(511/decay)*(\% annihilation)*(3.7E4)}}$$

denominator: constant for a run cycle: 1.28E+06

EXAMPLE OF "GMAP" SPREADSHEET LAYOUT, CONTINUED

SUMMARY INFORMATION .

STACK: ES-3 (53-03-03)

PERIOD: Dec-98

CONFIG: A1/A2 boost off, A2 Damper Open
A6 Boost on; A6 Damper open ; A1 lid closed
Delay Line & Scrubber Off; A6 direct

Total Number of Curies = 4941.654

Fraction of Total Curies (%)

f(C-10)	f(C-11)	f(N-13)	f(N-16)	f(O-14)	f(O-15)	f(Ar-41)
0.94%	42.74%	17.86%	1.69%	0.66%	34.62%	1.49%
						100.00%

Number of Curies

#Ci(C-10)	#Ci(C-11)	#Ci(N-13)	#Ci(N-16)	#Ci(O-14)	#Ci(O-15)	#Ci(Ar-41)	
46.40	2111.89	882.78	83.27	32.77	1710.81	73.74	4941.65

DOSE CALCULATION
(mrem/Ci: D. Fuehne 11/96)

8.64E-07	2.24E-04	1.87E-04	6.41E-10	1.26E-04	7.21E-05	3.03E-04

Dose Estimate (mrem)

4.01E-05	0.473063	0.165079	5.34E-08	0.004129	0.123349	0.022342

Total (mrem) = 0.788003